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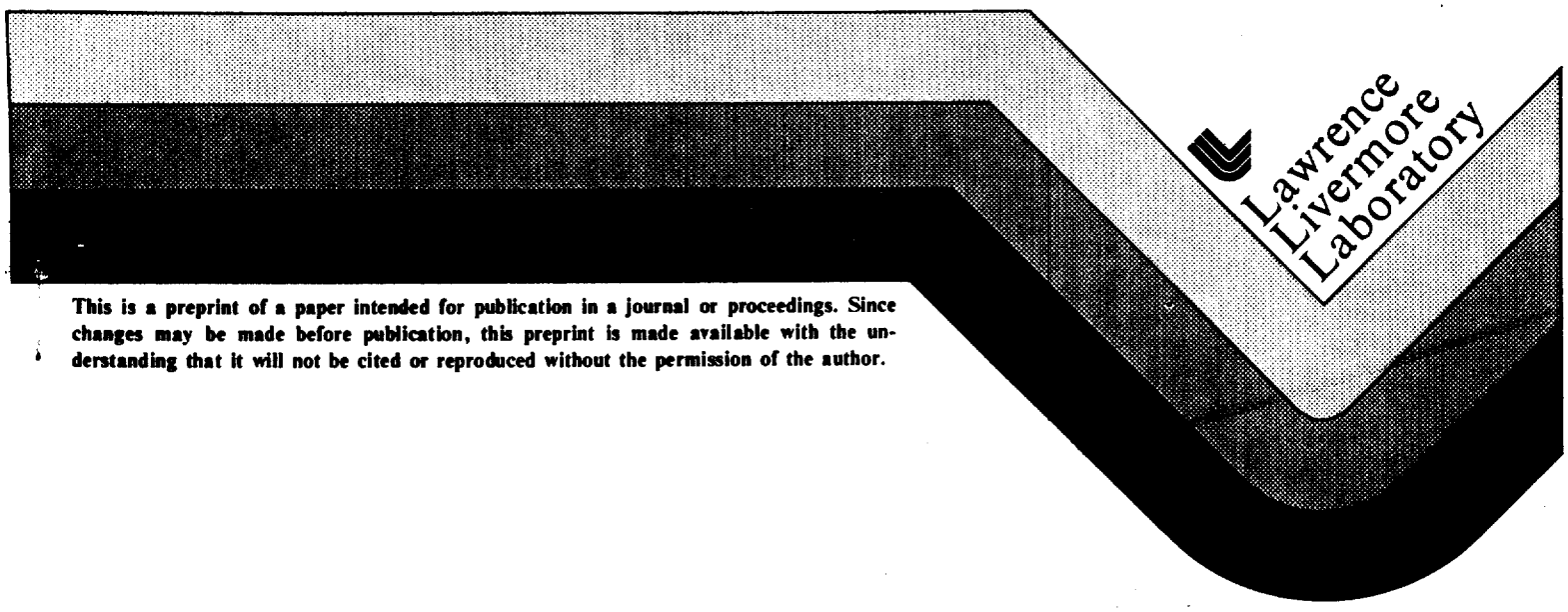

WARGAMING AND INTERACTIVE COLOR GRAPHICS

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ABSTRACT

JANUS is a two-sided interactive color graphic simulation in which human "commanders" can direct their forces, each trying to accomplish their mission. This competitive synthetic battlefield is used to explore the range of human ingenuity under conditions of incomplete information about enemy strength and deployment. Each player can react to new situations by planning new unit movements, using conventional and nuclear weapons, or modifying unit objectives.

Conventional direct fire among tanks, infantry fighting vehicles, helicopters, and other units is automated subject to constraints of target acquisition, reload rate, range, suppression, etc. Artillery and missile indirect fire systems deliver conventional munitions, smoke, and nuclear weapons. Players use reconnaissance units, helicopters or fixed wing aircraft to search for enemy unit locations. Counter-battery radars acquire enemy artillery.

The JANUS simulation at LLL has demonstrated the value of the computer as a sophisticated blackboard. A small dedicated minicomputer is adequate for detailed calculations and may be preferable to sharing a more powerful machine. Real-time color interactive graphics are essential to allow realistic command decision inputs. Competitive human-versus-human synthetic experiences are intense and well-remembered.

Introduction

The purpose of a simulation is to model the essential elements of a problem adequately so as to provide information that is valid within the context of the problem being addressed. For example, weapon or aircraft design codes do not exactly or completely model reality and yet they provide useful information to the designer. Military field exercises during peacetime are also a form of simulation. Here the element of fear is missing but this does not negate the usefulness of the simulation to the problem.

JANUS has been developed to simulate a tactical nuclear battlefield for gaining insights about how the use of nuclear weapons changes the face of battle. The essential elements of this problem are that terrain information be available, that more than one simultaneous viewpoint be considered, that a variety of scenarios be generated, and that the analysts be involved in the battle dynamics.

The decision to activity involve human input in all aspects of the model has lead to a strong emphasis on graphics. The computer provides a powerful "blackboard" for supporting the information storage and manipulation. The computer graphics provide the human link. Results of tactical decisions are immediately apparent and players can try many "what if" alternative decisions.

Simulation Fundamentals

JANUS is a two-sided interactive color graphic simulation in which human commanders can direct their forces, each trying to accomplish their mission. For efficiency, the Monte Carlo code is event driven rather than on discrete time steps. Since a "run of luck" in random acquisition/kill probabilities can be determinative of the outcome, several similar runs are necessary to have confidence in the outcome statistics

The terrain is created from digitized data tapes from the Defense Mapping Agency. For storage efficiency, the following terrain information is stored in the same word as each digitized elevation point: Foliage or city density, terrain destruction (rubble or blow-down), and presence of fire or smoke.

Scenario building with JANUS is user oriented. Players select scaled terrain from 10 km x 10 km to as large as 200 k x 200 km. Complete scenarios may be created interactively prior to running the model. Scenarios vary from small units to as large as a division-size force.

At any point in time, play of a simulation may be "frozen" on disk; later, players may "back-up" in time to try alternative decisions. The real-time, interactive nature of JANUS allows players to explore a variety of tactics and weapon systems.

Computer Graphics Fundamentals

The Conflict Simulation Laboratory (CSL) at LLL (see figure 1) consists of a Varian 16-bit minicomputer driving an Aydin frame buffer display system and interactive devices. The mini-computer is a single user system so only one simulation runs at any given time. Each simulation may use up to 160,000 words of memory by multi-tasking; each task is limited to 32,000 words. The display system controls two 512 x 512 x 6 bit raster pictures. Input is from a graph tablet, a function box, and the keyboard.

The graphic software is written in assembly language and FORTRAN. It is device-dependent, specifically written for the Aydin, the Summagraphics tablets, and the "home-built" function boxes. Most high level graphic functions, such as menu selection or dragging, are contained in the application itself.

The physical layout of CSL is shown in figure 2. There are two identical workstations, each in a separate room and a display area for controllers or viewers who can simultaneously observe both player perspectives.

Simulation Use of Graphics

The two color displays allow two independent views of the battlefield. Color is useful in distinguishing parameter which are meaningful conditions -- terrain contours, roads, rivers, foliage, cities, military units, and battlefield effects. Two-sided views aid in modeling the influence of competition. Interactive devices allow human versus human reactions. The display update is continuous except when a scenario is stopped to allow human command inputs.

The bulk of the graphic output involves line drawing, points, and character plotting. All data is displayed as 2-dimensional although some of it is stored and manipulated as 3D. Minimal use of conic sections are employed and only circles (as opposed to ovals, parabolas or hyperbolas) are used extensively. For example, in JANUS, an explosion is represented by the rapid display of a sequence of circles of increasing radius.

Programmable characters are used to display military units (tanks and helicopters). Such objects are dynamic in that they change position frequently. All terrain information is displayed by use of points or lines (trees, cities, smoke, or fires. As opposed to moving programmable characters, forest blowdown occurs less often and is displayed by drawing horizontal lines instead of dots.

Three basic types of input are used most frequently.

The function keyboard is used to enter different modes of operation or display. Light buttons or menus are provided on the display screen to enter different modes of operation within a selected function. Pick operations (or entity detect) are used to drag an object or to create a rubber-banded line.

User Interactivity

Movement commands illustrate the ways in which humans interact with an ongoing game. A player pushes a function box button labeled "PLAN" which halts the simulation and displays a picture of the currently operative future objectives. Group objectives are connected by line segments so that the player can:

1. Adjust objective positions
2. Add new intermediate objectives
3. Extend the path by adding new objectives
4. Cancel orders by merging objectives

Such "rubber banding" functions can be performed simultaneously on as many as five groups.

An alternative "units" interaction mode can be menu selected which allows redirection of the constituent units of these groups. The unit objectives are in coordinates relative to the (absolute) group objectives. This allows the players to plan the time evolution of unit "formations" as the group command objectives determine the large scale flow of an engagement. The code computes approximate times for achieving these movement goals and combines unit and group objectives by a "vector sum" rule.

When the simulation is resumed, units and groups attempt to accomplish these scheduled movements in either of two modes:

1) Subject to terrain, cover and engagement constraints, but along direct path segments.

2) Also allowing diversions to avoid obstacles and take limited advantage of roads.

In addition to the "PLAN" mode of interactivity, players can also select:

REPORT - to display the liner deployments of "elements" of a unit and bring up a current status report on each unit.

AUTO FIRE PLAN - to cause the code to do target planning on the basis of a "value map" of acquired targets.

NUCLEAR FIRE PLAN - to allows the player to manually "drag out" nuclear rounds from available source units and direct them at enemy units.

CONVENTIONAL FIRE PLAN - to allow the player to manually "drag-out" conventional indirect fire from available source units, such as artillery.

DISK I/O - to allow "instant replay" of a previously stored scenario, picking up the action from a specific point in time.

Study Utilization

In January-February 1980 a series of wargames were conducted by three analysts in an attempt to measure outcomes as available assets varied between scenarios. Players synthetically "lived" a total of 30 wargame, each requiring 1-1/2 to 2-1/2 hours of computer time.

The study provided a rigorous test of JANUS in its ability to go beyond allowing players to visualize battle. A methodology was developed to measure differences in outcomes as the assets available to players varied. Success for players depended on mission completion - not solely on attrition statistics.

The methodology was designed to compensate for variable degrees of player experience by variation of pairs of players opposing each other and by alternating sides. The tactics used by the players were not constrained to "doctrine" and the free play resulted in a wide variance in outcomes--primarily due to the tactics of the players.

The interactivity and flexibility of the code allowed this methodology to be practicable. In essence, 30 completely different wargames were conducted. Players were able to continually direct their forces as each engagement occurred. Players strived to add a very important ingredient into their tactics — surprise. To achieve this, players wer able to test their creativity and imagination. Often their plans proved futile and resulted in failure, however, each player learned from his failures because he was able to visualize the "battle" and learn the causes of his failures.

Observations

The choice of information to display emphasizes only certain aspects of the behavior being simulated. As the attempt to involve the human increases, so does the desire for "realism." A simulation such as JANUS is then faced with the problems of a cluttered display with ever increasing amount of information to present.

As with any computer simulation, the graphic simulations are highly dependent on the clear understanding by users of the underlying assumptions. In fact, the graphics may tend to exaggerate a problem by allowing the user to feel comfortable that he/she is seeing everything. Novice players may make misleading conclusions as a result of assuming or ignoring non-existent parameters.

JANUS contains several simplifications which may not be immediately obvious. Automated conventional fire is directed at the closest enemy threat. When symbols are played as aggregates, such as ten tanks, the interactions of individual elements must be "sampled" rapidly in time. Visual acquisitions require line-of-sight but are probabilistic. Limited numbers of "units" (40) limit the scale of the engagement normally to brigade level.

Conclusion

JANUS has been able to compete with simulations run on large main-frame computers, even thought it runs on a modest mini-computer. This experience suggests that it is often preferable to have full control over a small dedicated machine rather than to compete for large machine time. The contributing factors seem to be:

1) A small mini-computer is adequate, in both memory and CPU speed to run a sophisticated simulation.

2) Graphics interactivity requires at least a minimal real time local CPU capability to handle user inputs and fast display devices.

3) The hardware/software configuration of a dedicated machine can be optimized for the particular application.

The fact that analysts are able to visualize the battlefield situation, to compete in timely decisions and to play a variety of combinations has aided study of the integrated nuclear conventional battlefield. The essential elements are present for intense competitive experiences, stimulating the best efforts of human ingenuity.

References:

1. "JANUS", Buzzell, Calvin and Smith, George, January 1980
2. "Conflict Simultation Laboratory - II. Part 1. Functional Requirements", Ames, H. S., Bly Sara, et al, UCID 18494 Part 1, November 1979.

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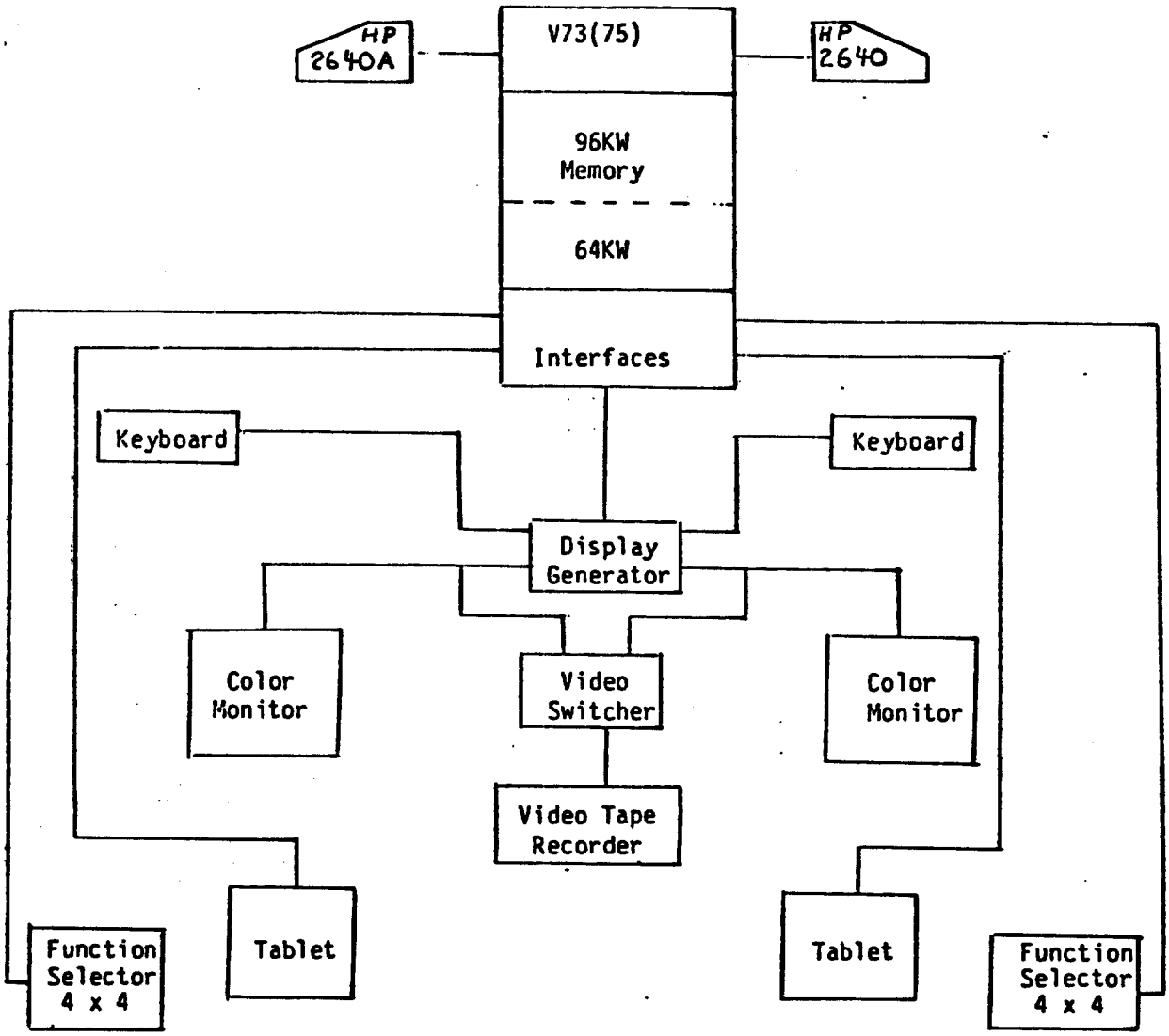

Figure 1. Overview of CSL Hardware

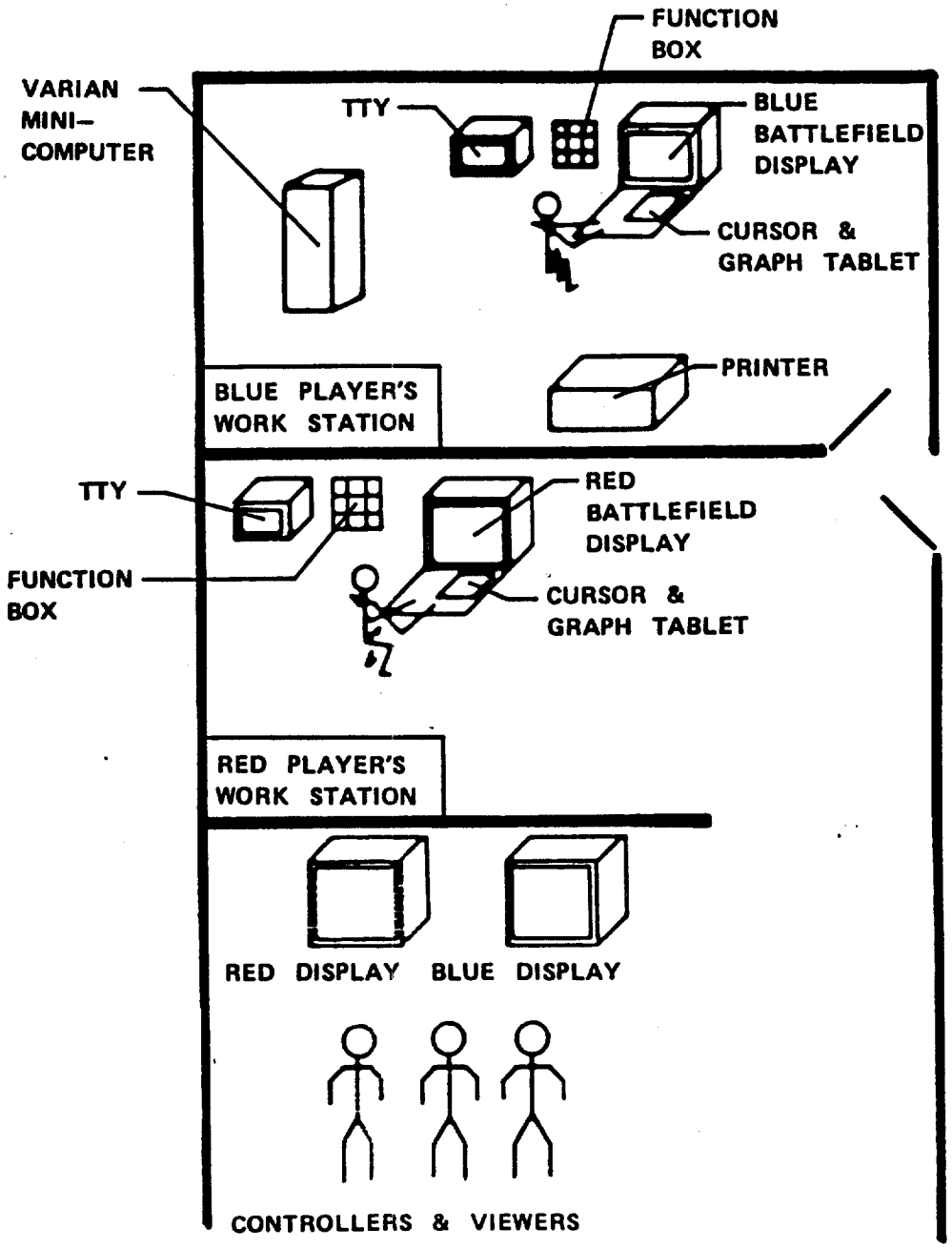

Figure 2. CSL Layout